"What happens when computers become a significant resource in classrooms?

How does a critical mass of technology affect the way teachers teach and learners

learn?" These were the questions that were raised when the ACOT project began.

For more than a decade, researchers, practitioners, and technology developers

have been able to work together to increase our understanding of what can happen

in classrooms when powerful technology and effective instruction are joined.

The lessons learned provide a rich foundation of experience and knowledge to

guide current investments in technology at the local, state, and national level.

*—Linda G. Roberts, Director, Office of Educational Technology,*
*U.S. Department of Education*

Because of ACOT and the technology,

I continue to be enthusiastic about

being a teacher. But I am an altogether

different teacher than I was before. I am

now guiding the students. They are the

masters of their own education now,

creating their own knowledge and using

their creativity to research and explain

information to others.

*—Chris Stortz, ACOT Teacher,*
*Stevens Creek Elementary School, Cupertino, California*

**What we observed was the reality that multimedia and multiple layers of information helped students more thoroughly and more dynamically explore ideas.**

—Robert J. Tierney, Professor and Chair,
Educational Theory and Practice,
The Ohio State University

**Using technology as a motivator for change and a tool for teaching and learning, today's ACOT Teacher Development Centers engage teachers in the same kinds of challenging and collaborative learning activities that they aim to provide their students. As such, these centers are an evolving solution to the most pressing dilemma facing education reform: how to spread the accomplished practice from a few teachers and schools to many.**

—Dr. Jane L. David,
Director, Bay Area Research Group, Palo Alto, California

## 1985

### Initiating ACOT

Educators at Apple initiated a research project to answer the question: What happens to students and teachers when they have access to computers whenever they need it? This meant that the technology was always available—not down the hall in a lab, and not left behind when students went home after school.

First sites selected—one classroom each in Eugene, Oregon, and Blue Earth, Minnesota. ACOT supplied the computers and trained the teachers. Our district partners paid for staffing, physical modifications to the classrooms, and extra insurance.

## 1986

Additional sites were added in Columbus, Ohio; Cupertino, California; Houston, Texas; and Memphis and Nashville, Tennessee.

First public presentations about ACOT—at MECC and AppleFest.

The ACOT Senior Scholars Conference, attended by a group of distinguished researchers, developed a research agenda for ACOT.

## 1987

The sites at Houston and Eugene were closed in favor of adding more classrooms at the other sites.

The ACOT Teacher Summer Conference gave teachers at the ACOT sites an opportunity to meet, share experiences, and learn more about teaching with technology.

### 1986–87: The start of longitudinal research*

We knew that changes in teachers—and in schools—happen over time. During the first two years, we simply observed what was happening in the classrooms.

- ACOT teachers used word processing and electronic mail to send weekly reports from each site to ACOT staff at Apple. And each teacher sent monthly audiotape journals to the researchers in which they expressed their personal frustrations as well as their victories.
- ACOT researchers developed a database to store the information—without losing any of the descriptive quality—and began looking at major themes.
- Eva Baker (UCLA Center for Technology Assessment) began examining the impact of the ACOT program on students, staff, and parents.
- Robert Tierney (The Ohio State University) began a longitudinal study of the thought processes of ninth-graders at the ACOT high school site—exploring the potential of technology as a tool to strengthen and expand students' thinking skills.
- Elfrieda Hiebert (University of Colorado) collaborated with an ACOT third-grade teacher to describe and assess a computer-intensive writing curriculum.

*ACOT research reports are available on many of these topics. See "Where to get more information" at the end of this report.

## 1988

We continued to add classrooms at the sites.

ACOT research studies were presented at the American Education Research Association (AERA), the International Reading Association (IRA), and the International Association of Computing Educators (IACE).

ACOT was featured in a report on the use of technology in American schools published by the U.S. Office of Technology Assessment.

## 1989

We focused on three sites—Columbus, Cupertino, and Nashville—so we could learn more by working intensively with fewer schools. We also continued to add classrooms so we could follow students through more grades.

We published reports on Hiebert's writing research, on the first two years of Tierney's longitudinal study of students' thinking, and on Fisher's study of student empowerment.

We began preliminary work on a teacher development model at the Nashville site.

Visitors from South America and the USSR toured ACOT sites.

ACOT was cited in articles in USA Today, The New York Times, Business Week, Boston Globe, and the Japanese counterpart of PC Magazine, and featured on NBC Nightly News.

### 1988–89: Continuation of longitudinal research

e introduced multimedia at the sites and continued our observations, finding themes that we anted to address more fully.

Recognizing that teachers' practice was becoming more learner centered, we began focusing our staff development sessions to encourage a constructivist approach to teaching.

We started an investigation of the interrelationships among learning, computers, and space.

We realized the limitations of traditional assessment measures for capturing the changes we saw in the ACOT students.

We also discovered that the students were developing a variety of new competencies not usually measured.

We began developing a common language to help teachers collaborate more effectively.

### 1988–89: Expansion of research collaboration

e began funding the work of researchers at other institutions whose projects addressed issues nd themes we had found in the observational research.

In alternative assessment, we began working with Allan Collins (Northwestern University) and Jan Hawkins (Center for Children and Technology) and continued our relationships with Tierney and Baker.

In writing, we began collaborating on a language arts assessment tool with Midian Kurland (Educational Development Center) as well as on telecommunications-based writing workshops for teachers.

In task design, we began working with Charles Fisher (University of Colorado) on creating projects that empowered students and on the associated needs for staff development.

In staff development, we worked with Jean Marsh (Vanderbilt University) on a new staff development model for ACOT teachers.

## 1990

We published reports on Baker's two-year evaluation study and Confrey's development of Function Probe and a problem-based mathematics curriculum. We also published our four-year study of the evolution of teachers' beliefs and practices and our study of classroom management—both by Dwyer, Ringstaff, and Sandholtz. And we made presentations on several research projects at AERA.

## 1991

• Presentations to the U.S. Department of Education, President's National Education Goals Committee, National Governors Association, Education Commission of the States, National Center for Education and the Economy, Fortune 500 Magazine Education Summit, Federal Communications Commission, and Smithsonian Computerworld program

• Presentations at regional and national conferences including the American Education Research Association, American Psychological Association, National Education Computing Conference, Computer-Using Educators, International Reading Association, American Association of Physics Teachers, American Math Society, National Science Teachers Association, and the Cognitive Science Society

• Article in Educational Leadership on changes in teachers' beliefs and practices

### 1989–92: Encouraging new uses of technology

Technological advances now allowed developers to create tools that represented ideas in multiple formats—text, images, video, graphics, tables, and charts. We began collaborating with researchers who were developing multirepresentational tools that could aid in knowledge construction. The product list included Function Probe, Science for Living, Geometry Tutor, Physics Tutor, Digital Image Processing, and TableTop.

We also began working with researchers at the Ontario Institute for Studies in Education on CSILE, a computer-supported collaborative learning environment for children.

**1992  1993  1994  1995**

## 1990–95: Amplifying our voice

Realizing that more people needed to hear what we'd learned about teaching and learning with technology—especially about the need for new forms of assessment and new approaches to staff development—we increased our speaking engagements beyond the community of educational researchers. We also began responding to requests for information from state and national policymakers.

**[1992]**

- Presentations at meetings of the American Education Research Association, American Psychological Association, and the California Business Roundtable
- Presentations to the commissioners of education and their staffs for Kentucky, Vermont, New York, Indiana, and Ohio
- Presentations to 11 Soviet Republic Ministers of Education

**[1993]**

- Presentations to several state boards of education and legislators
- Briefings to educators and policy makers from the United Kingdom, Singapore, Japan, Bulgaria, Saudi Arabia, Turkey, Portugal, Poland, United Arab Emirates, Hungary, and France
- More than 25 national and regional newspapers, magazines, and TV stations—including the Wall Street Journal, The New York Times, Forbes Magazine, and Education Week—cited ACOT as a reference.

**[1994]**

- Presentations to the U.S. Office of Technology Assessment and the Council of Great City Schools
- Presentations to a variety of educational reform groups, including the New America Schools governing board, National Alliance for Restructuring Education, ATLAS project, and the Coalition for Essential Schools
- Presentations to ministries of education for New Zealand, Singapore, and the European Commission
- Article in Educational Leadership on lessons from ACOT classrooms
- Distribution of ACOT research summaries to 40,000 educators

We published Stuebing's report on physical environments for learning with technology; Ringstaff, Wilmore, and Yocam's reports on the pilot program and first year of the ACOT Teacher Development Centers project; Sandholtz and Ringstaff's report on student engagement; and a report on the MediaFusion project. We made presentations on ACOT-related research at conferences in London, Boston, St. Petersburg, and San Francisco.

**[1995]**

- Presentations to ministries of education in Denmark, Sweden, India, Bolivia, Scotland, Great Britain, Chile, Australia, and New Zealand
- Meetings with the commissioner for education of the European Union
- Participation in a PBS series on education

## 1990–93: Developing integrated environments

Realizing that technology—and especially wireless technology—could have an especially strong impact in the areas of collaboration, communication, and the construction and expression of knowledge, we used the results of our research to create specific learning environments that demonstrated the integration of these areas. Then we produced short videos to document the projects.

- The project known as "Wireless Coyote" explored the use of mobile, networked, and multirepresentational technology—as well as the effects of a constructivist environment—during a science field trip for middle school students.
- The project known as "Cloud Forest Classroom" replicated Wireless Coyote in another location and with other students. For this study, we developed and tested an integrated data collection, data analysis, and messaging environment to support collaborative field activities.
- The project known as MediaFusion involved an integrated environment that allows developers to make conventional TV broadcasts explorable by computer. It gave teachers, students, researchers, and our partners at the Public Broadcasting System (PBS) a view of how interactive TV might some day be used for learning.

## 1990–95: Developing additional partnerships

- With the National Science Foundation, we established ACOT Teacher Development Centers at three sites in order to investigate more fully the effectiveness of this new approach to professional development.
- With the National Alliance for Restructuring Education, we created a network of Teacher Development Centers in participating schools. This allows us to work in environments in which restructuring is already under way and also to see how the staff development model can be replicated on a larger scale.
- With the San Francisco Exploratorium and a local school district, we are investigating how elementary school teachers can use a multimedia messaging system and a media-rich environment to enhance communication, collaboration, and inquiry.

We published a report on five years of Tierney's longitudinal study of the influence of high computer access on students' thinking, learning, and interactions. We also published reports by Ringstaff, Sandholtz, and Dwyer on the relationship between technological innovation and collegial interaction and on the classroom results of teachers using students' technology expertise. We published a report on the school-university-business partnerships that make up ACOT, as well as a report on a second-grade multimedia-composing project.

# 1996

*For the past 10 years, Apple has sponsored a research project called Apple Classrooms of Tomorrow (ACOT) that is investigating the relationship between technology and education. The ACOT experience has been unique for us. The research is exploratory and open-ended. And, over the years, it has brought us into partnership with students, educators, and researchers throughout the nation.*

*We'd like to use what we've learned in ACOT to change the conversation about technology and education. Instead of talking about computers, for example, we talk about learning. We describe what happens when students use technology as a tool for building their own knowledge—and examine the impact on the kinds of skills they develop. We discuss how teachers can use technology to create more challenging learning environments—and suggest a staff development process that can facilitate that. And we explore ways to deepen our understanding of how technology can be used as a tool for learning.*

*This is a work in progress. The following report presents some of the ACOT findings and suggests the implications they have for education. But there's always more to be learned.*

*David C. Dwyer, Ph.D.*
*Distinguished Scientist*
*Apple Classrooms of Tomorrow*

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# vith a

## WHAT HAPPENS TO STUDENTS AND TEACHERS

# question:

## WHEN THEY HAVE ACCESS TO TECHNOLOGY WHENEVER THEY NEED IT?

During the mid-1980s, a time of great excitement about using technology to enhance education, educators at Apple proposed a simple experiment. They would create environments in which technology was used as routinely as paper and books—and then observe the effects on teaching and learning.

Working with partner districts, they selected schools and classrooms, and they gave two computers to each student and teacher—one for school and one for home. (In those days of bulky equipment, this was the only way to provide immediate and routine access.)

From the outset, the investigation team was composed of university-based researchers, ACOT staff members, and teachers—who played an important role in describing classroom changes. With electronic mail and audiotape for communication, and encouragement to reflect on their experiences, the teachers flooded the ACOT staff at Apple with their observations. As the volume of communication grew, the ACOT researchers developed a database for the anecdotal data and began investigating themes relating to technology and change. Researchers from other institutions also began to conduct investigations in the ACOT settings.